Communication Matters:
Lessons in Engineering Safety
from the Deepwater Horizons Disaster

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October 21, 2010

The Argument in a Nutshell

Analysis of communication practices can help

- Identify gaps in Fault Management and Safety.
- Develop more effective risk management plans and procedures
- Reduce administrative burden

Rhetoric is the art of finding out the available means of persuasion.

-- Aristotle

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Risk Communication: The Big Picture

1. **An on-going process** of assessment, planning, training, monitoring, maintenance, and evaluation involving stakeholders at all levels of the company;
2. **A written plan** to guide communication and decision-making in a crisis.
3. **Emergency action** to control outcomes, reduce damage, save lives.
4. **After-the-fact strategy** for managing the public face of the crisis.

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Risk Communication: Where BP Failed

1. **After the fact process** of assessment, planning, training, monitoring, maintenance, and evaluation involving stakeholders at all levels of the company;
2. **Emergency Action Plan = Communication Plan** to guide communication and decision-making in a crisis—without case-by-case scenario planning.
3. **Overly Confident Reliance on Technology (BOP)** that did not take into account the possibility of failure → inadequate action to control outcomes, reduce damage, save lives.
4. **Poorly Developed After-the-fact Strategy** for managing the public face of the crisis.

Background:
The Rhetoric of Risk
(Sauer, 2003)

The Cycle of Documentation in Large Technological Systems

Translation and Transformation for New Audiences

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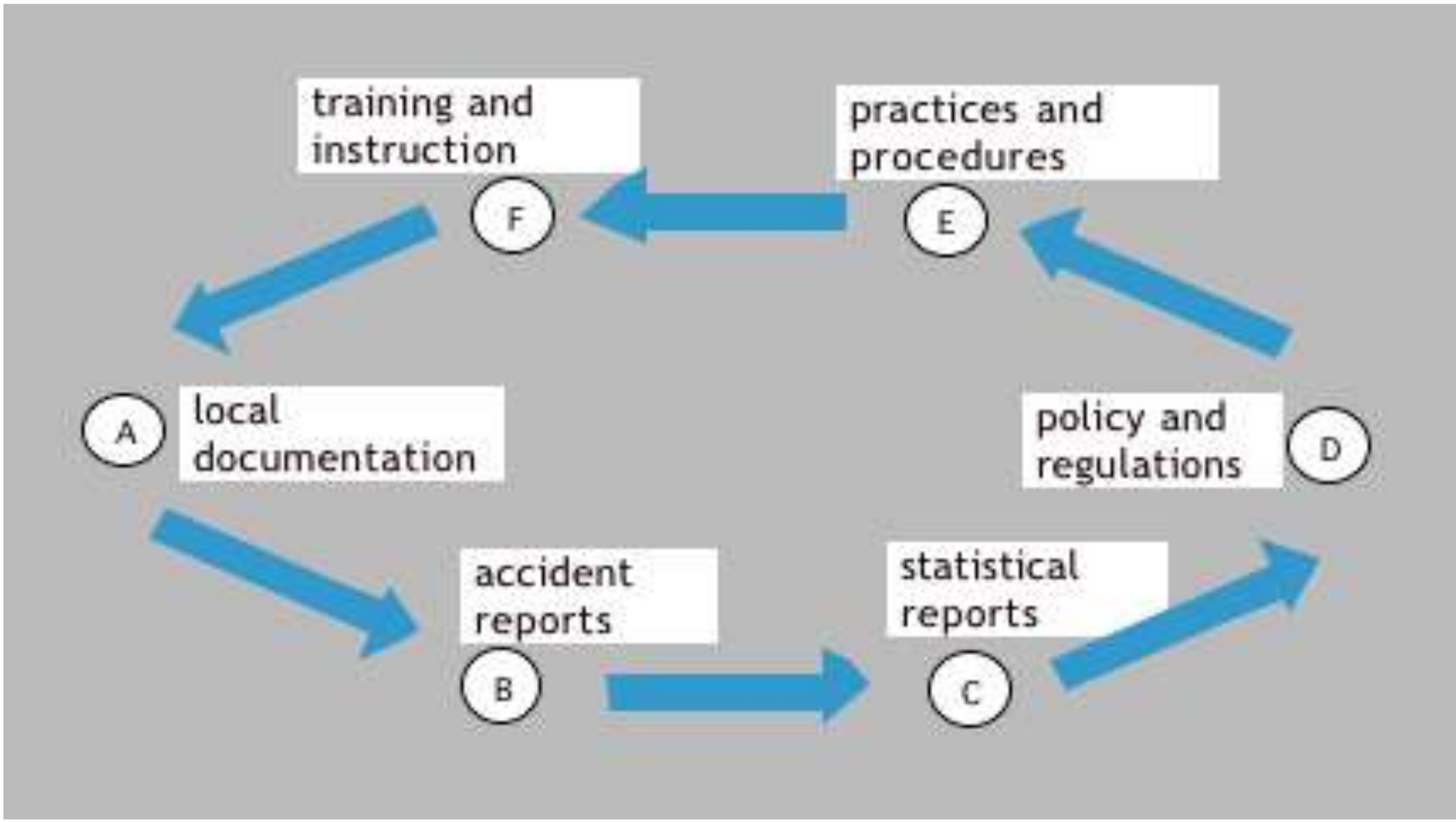
Communication Practices Have Long-Term Effects in Large Systems (Sauer, 2003)



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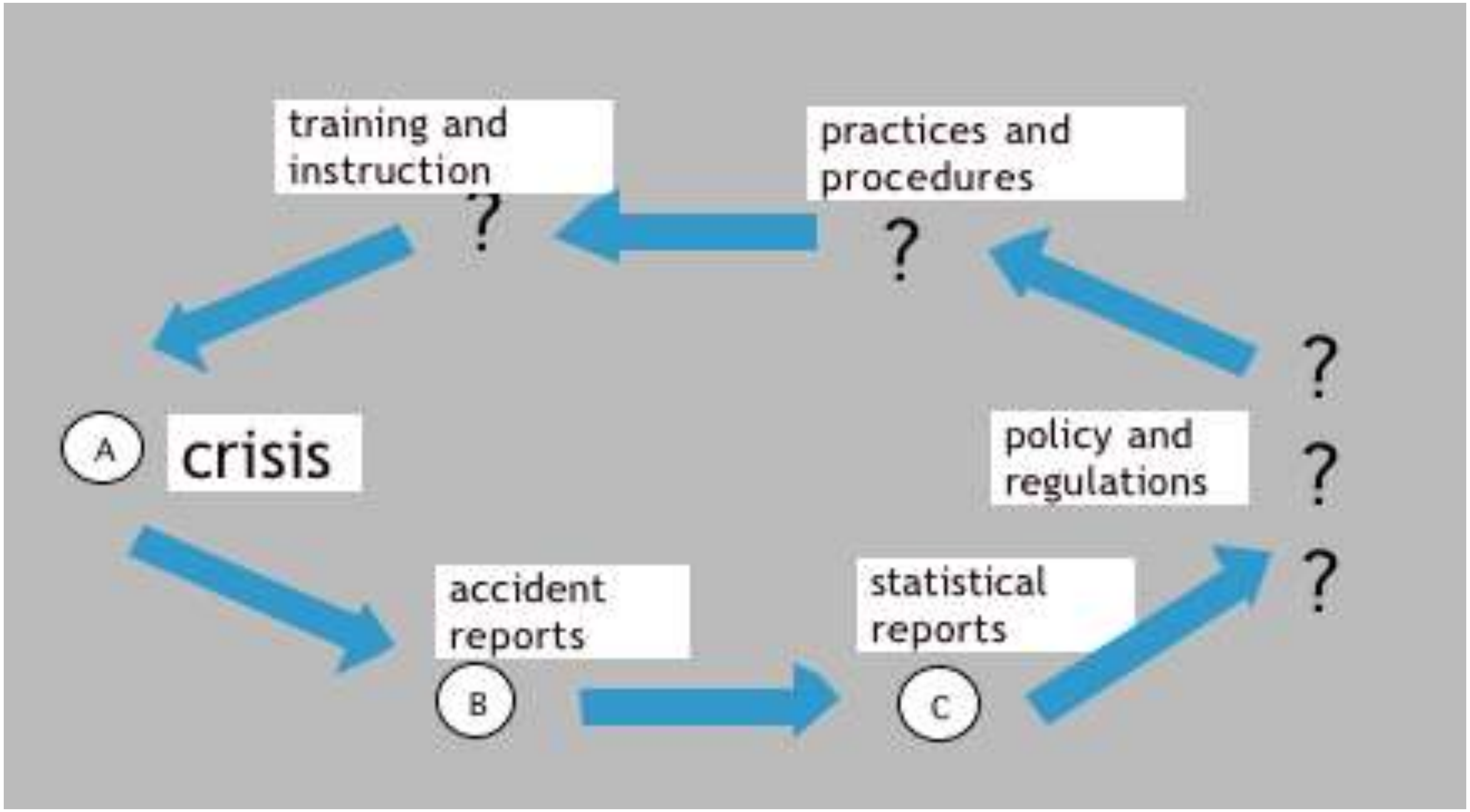
Crises Reveal Gaps in Communication and Leadership

(Sauer, 2003)



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Local Knowledge is Rendered Invisible—and Unrecoverable--in Written Documentation

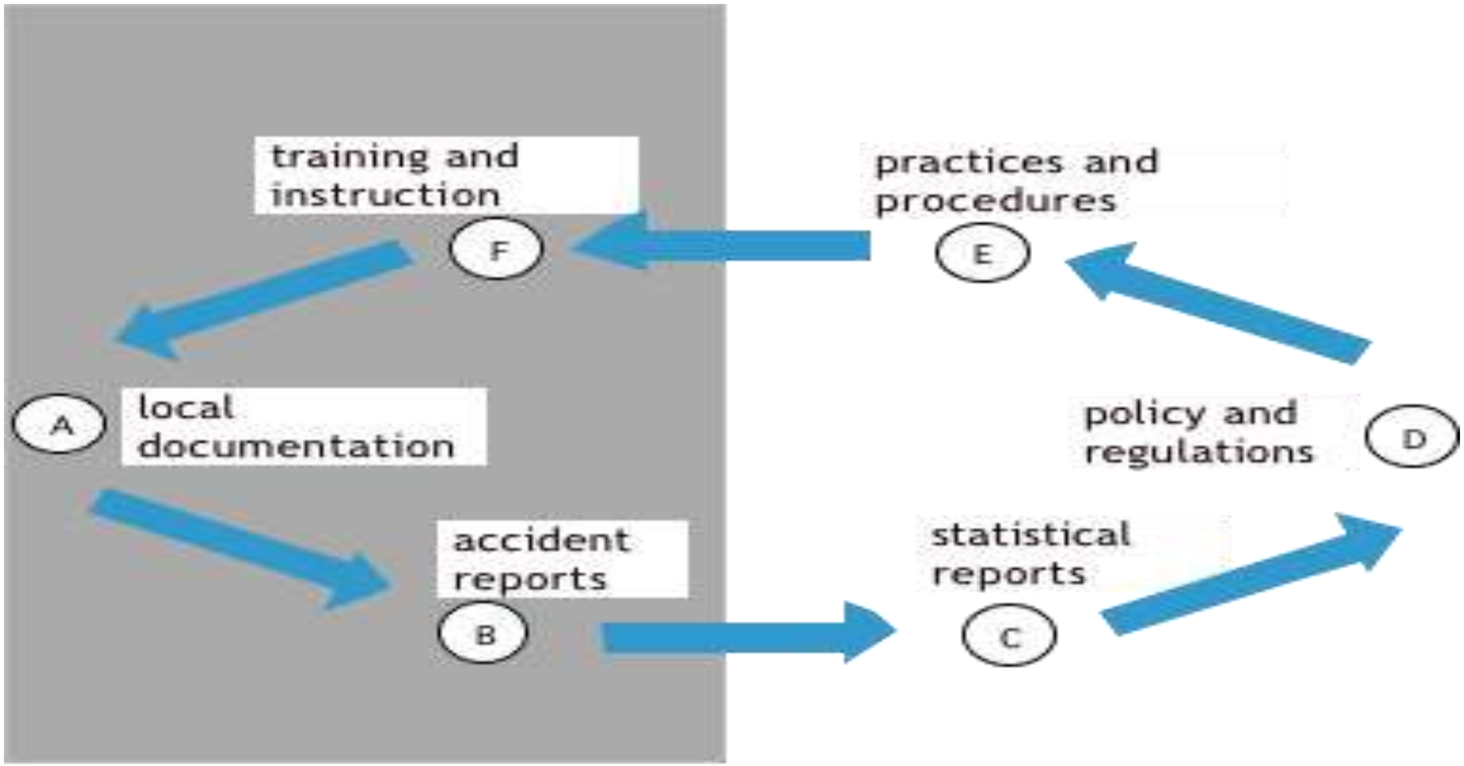

Figure 2.6. The Rhetoric of Risk focuses on the rhetorical transformation and re-transformation of experience at the boundaries between agencies and experience.

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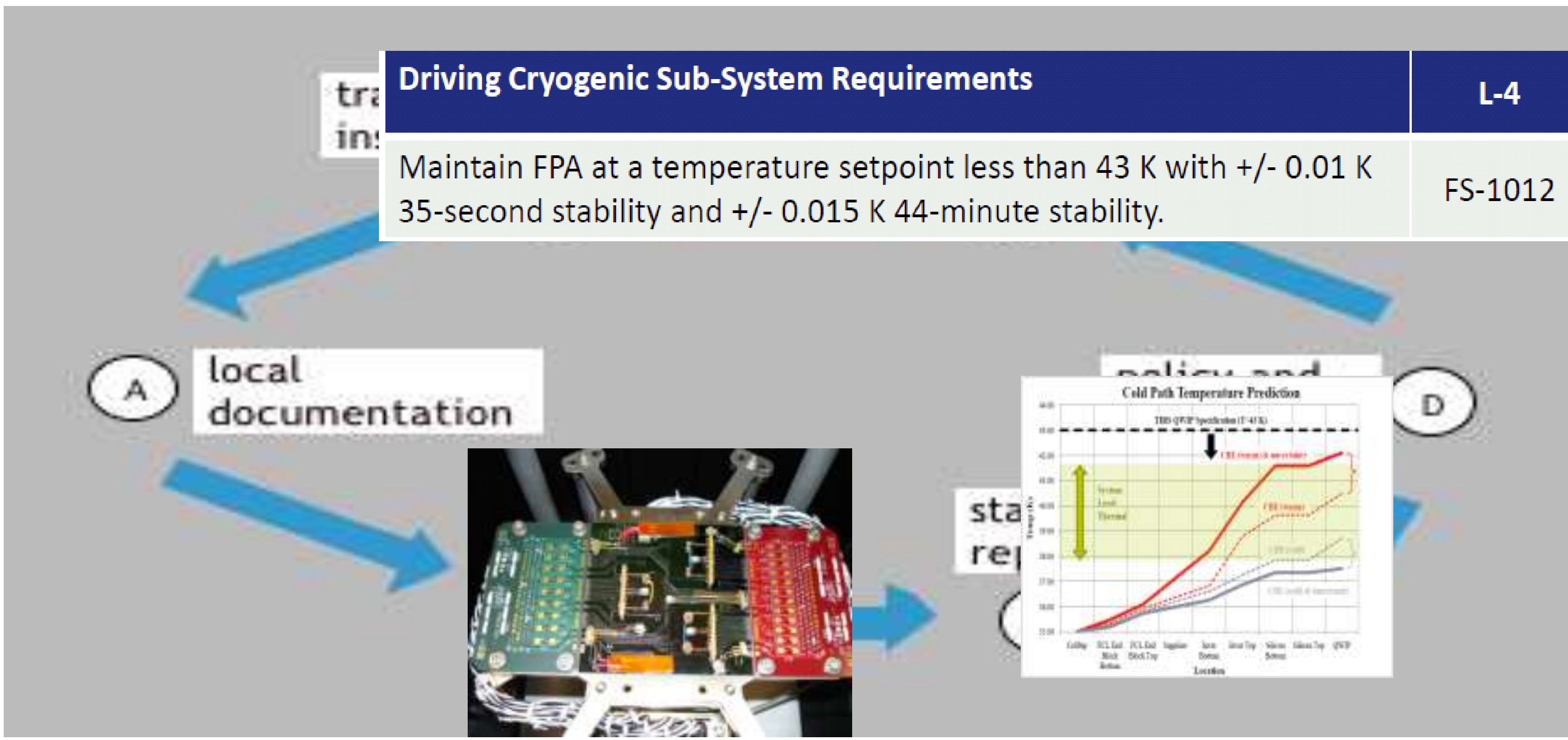
Problem 1: Distributed Cognition

How Can we Capture and Interpret the Tacit Mental Models & Technical Assumptions Not Captured in Written Record?

Driving Cryogenic Sub-System Requirements	L-4
Maintain FPA at a temperature setpoint less than 43 K with +/- 0.01 K 35-second stability and +/- 0.015 K 44-minute stability.	FS-1012



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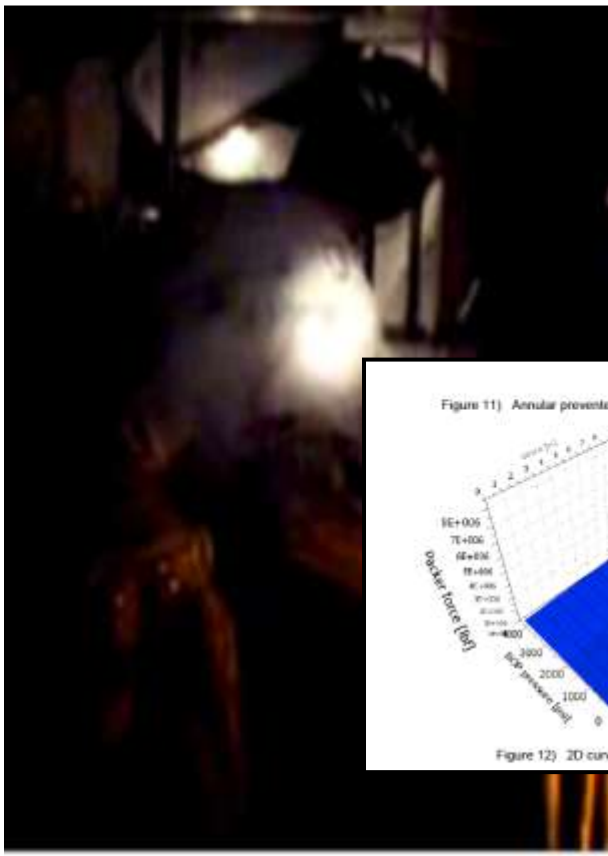
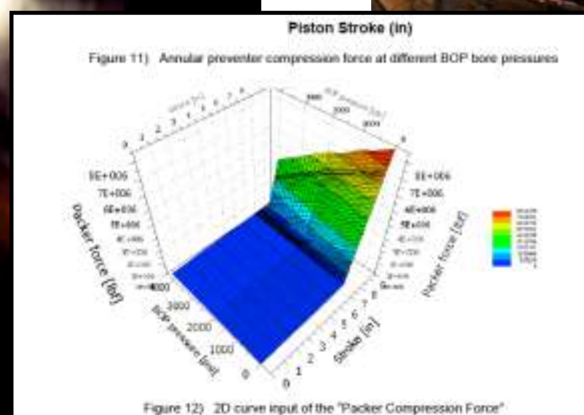
Problem 2: Capturing Local Knowledge

How can we reconcile formal scientific data with the dynamic uncertainty of local environments?





Source: Underground vision [automated surveying robotics]. Engineering & Technology (17509637), 11/21/2009, Vol. 4 Issue 20, p44-47, 4p, 3 color Color Photograph; found on p45 part. 2 (Incomplete) ; http://www.youtube.com/watch?v=1cUR0DDaEig

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Problem 3: Administrative Burden

- **New technologies require new regulatory expertise.**
  - Transocean's Enterprise Class Drill Ships, for example, set new standards for efficiency and cost savings in the deepwater drilling industry. The company used radically new technologies to increase production. Such changes require updates to regulatory practices and procedures, but regulatory processes may be too slow to prevent disaster.
- **Political realities can also undermine the intent of federal regulation.**
  - The Outer Continental Shelf Lands Act specifies that lease applications must consider the social, geographical, geological, and ecological characteristics of the region (sec. 18). But the act allows regulators to override environmental and social concerns in striking a "reasonable balance" between the nations' energy needs" and the "well-being of the Citizens of the affected states" (sec. 19).
- **Data is expensive, uncertain and quickly outdated.**
  - **Increases in production reduce risk mathematically — if risk is measured in fatalities per barrel, for example — but they increase the magnitude of any potential disaster**.

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Problem 4: Regulatory Fragmentation

- **Regulatory authority is dispersed across multiple agencies.**
- **As a result, regulators may lack a big picture view of risks.**
  - Several federal environmental laws govern oil spills, for example, including the Endangered Species Act, the Clean Air Act, and the Oil Pollution Act. The Mine Act of 1978 (CFR 30) regulates mine safety, but not oil spills.
  - The Outer Continental Shelf Lands Act includes general provisions for safety, but focuses on offshore lease management and resource development.

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Problem 5:

Lack of Big Picture Thinking Obscures Lines of Authority and Accountability

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Brief Overview of the Disaster:
The Rationale For Risk Decision-Making

PV = (?)

PV = nRT

PV = Present Value

Engineering vs. Business Calculations
Grounded in Uncertainty about the Material Conditions that Precipitate Disaster

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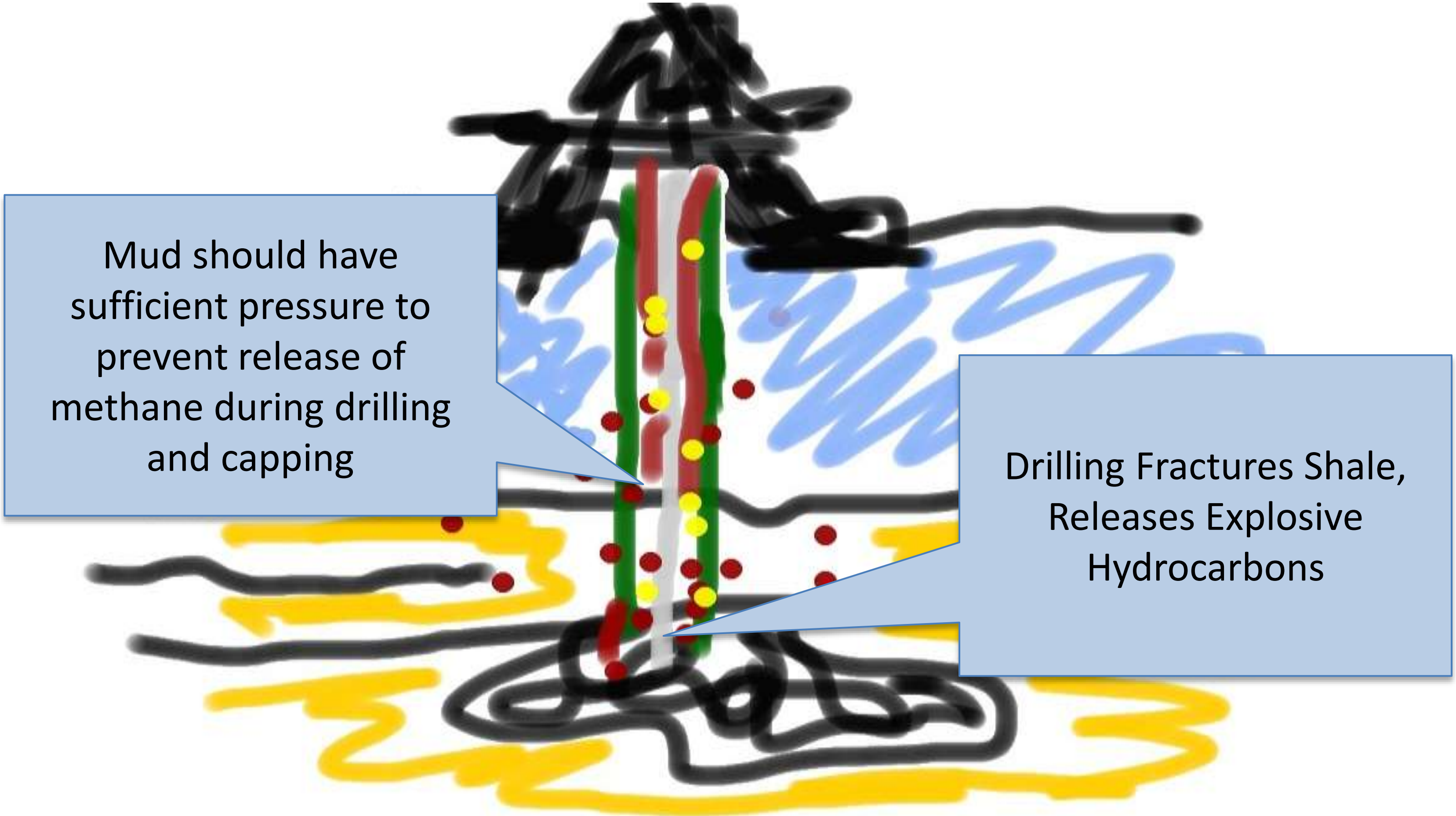
The Drilling Environment: CH4



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Basic Mine Precautions for Gassy vs. Non-Gassy Mines Ignored

- Methane detectors disrupted
- No remote cut-off valve
- Dependence on (untried) robotic cut-off as 2nd line of defense

Google Image Result for http://news.xinhuanet.com/english2010/world/2010-10/13/13555973_11n.jpg

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Methane Explosion Destroys BOP/Annulus

Google Image Result for http://www.treehugger.com/20100506-deepwater-horizon-fire.jpg

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What Caused the Disaster

Lack of Big Picture Thinking

Lack of Local Risk Mgt Plan—No Backup Plan

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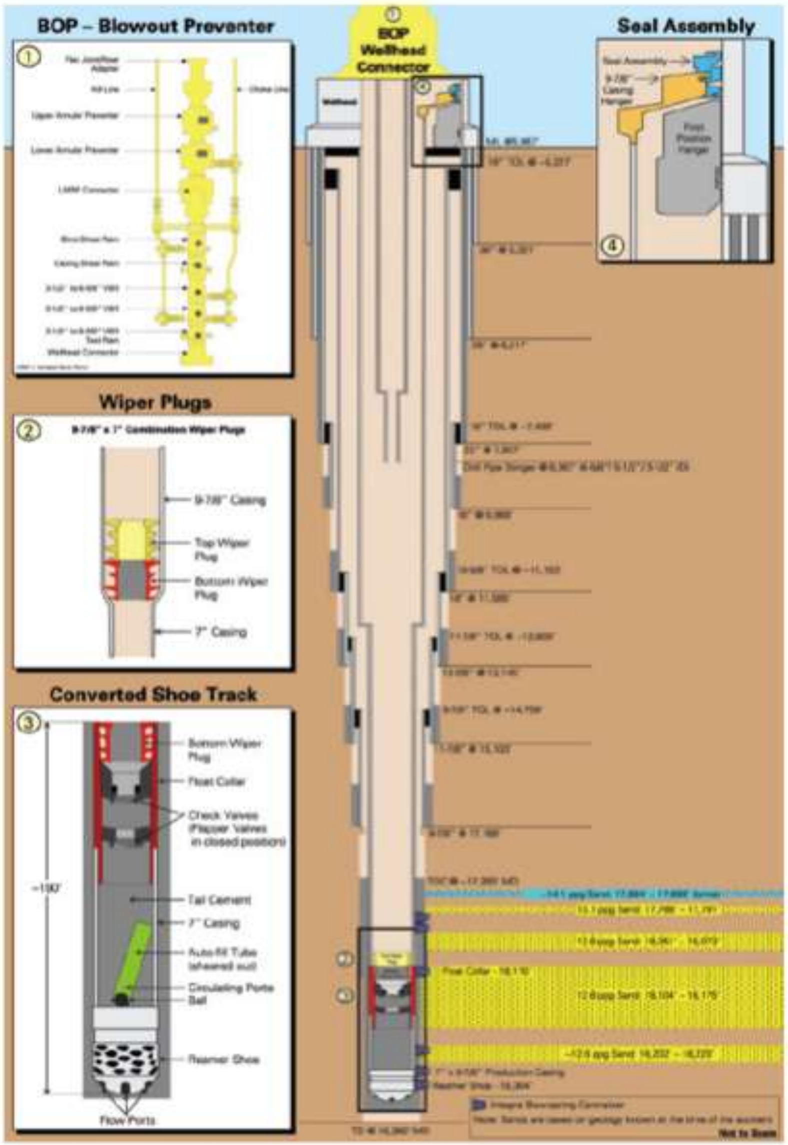
Appendix C. Macondo Well Components of Interest

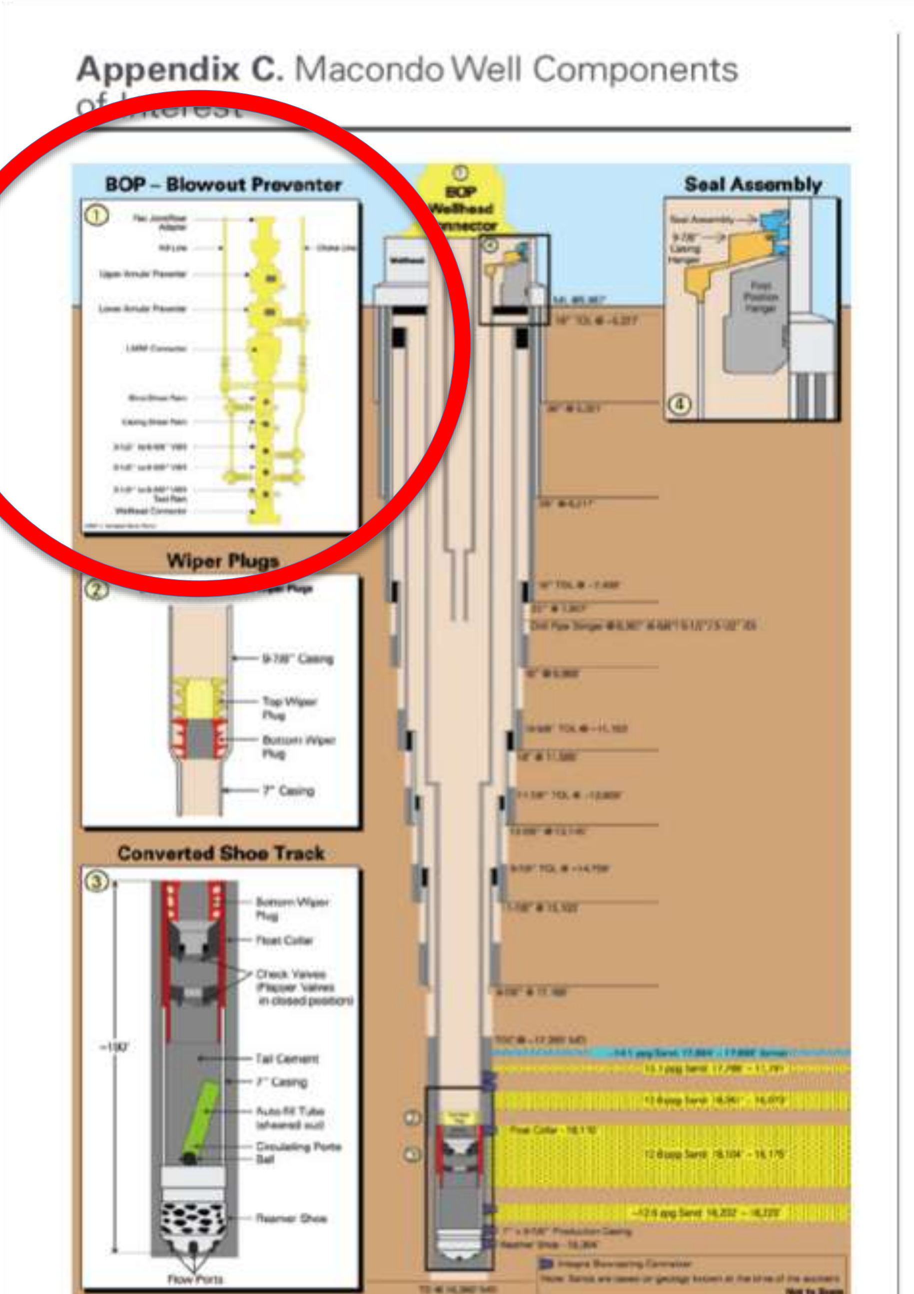


The Hubris of Technology:

Overly Confident Assessment of BP’s Blow-Out Protector (BOP)

Actual Risk of BOP

- 3/14 Failure Rate for new parts
- 10 % Failure Rate at Joints
- Most dangerous during Drilling & Cementing Operations
- Maintenance Critical
- New Carbon Steel Drill Bits reduce BOP effectiveness



Idealized Visual Designs Obscure BOP Mechanism + CH_4

Visible Design Flaws

- Lack of coordination between drawing and insets
- Yellow design of inset obscures details of BOP mechanism
- Focus on technology obscures shale/sand environment
- No indication of methane, gases
- Diagram shows how it *works*
- Mud, gasses absent from idealized view

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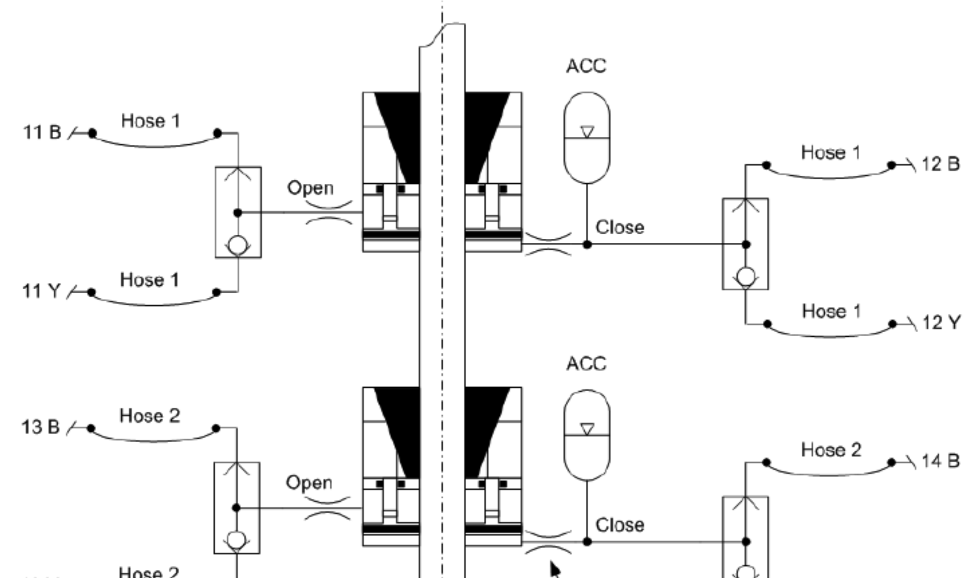
‘Experiential’ Risk Estimations

(Appendix Z. Hydraulic analyses of BOP Control System)

4.9 Upper and Lower Annular Preventer Controls



4.4 Accumulator Racks

Need more info about tubing and valves.

Description	Value	Unit	Reference
Surface supply accumulators			
Volume pr. bottle	40	USgal	Meeting 06/24/10
No. off bottles	45	-	Meeting 06/24/10
Pre-charge pressure – N2	2000	psi	Meeting 06/23/10

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Future-Tense Models & Simulations

3.2 Scenario 2: Parallel operations with reduced LMRP accumulator capacity

Case No.	Description	Results of interest
Case 2-1	One Annular Preventer closed at 1500 psi. Close the second Annular Preventer.	Pressure variation in the close cavity of the first closed preventer.
Case 2-2	One Annular Preventer closed at 1500 psi. Close the second Annular Preventer together with one VBR.	Pressure variation in the close cavity of the first closed preventer.
Case 2-3	One Annular Preventer closed at 1500 psi. Close the second Annular Preventer together with two VBR's.	Pressure variation in the close cavity of the first closed preventer.

All cases in scenario 2 shall be simulated with a) reduced pre-charge pressure and b) correct pre-charge pressure but with reduced accumulator volume (one bottle out of gas)

3.3 Scenario 3: Parallel operations with high BOP pressure

Case No.	Description	Results of interest
Case 3-1	One Annular Preventer closed at 1500 psi. Close the second Annular Preventer.	Pressure variation in the close cavity of the first closed preventer.
Case 3-2	One Annular Preventer closed at 1500 psi. Close the second Annular Preventer together with one VBR.	Pressure variation in the close cavity of the first closed preventer.
Case3-3	One Annular Preventer closed at 1500 psi. Close the second Annular Preventer together with two VBR's.	Pressure variation in the close cavity of the first closed preventer.

Well pressure build-up shall be included to replicate the real conditions as close as possible.

Poor Maintenance vs. Idealized Test Results

- **Conclusion—Appendix Y**
  - The audit found a total of 31 findings related to well control maintenance.
  - The audit findings suggested potential weaknesses in maintenance planning & work execution.
  - The audit team also found the recording of maintenance activities to have been insufficient.

‘Orphan Designs’ in Real-Time Operation

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Lack of Common Sense Engineering

Item No.	Audit Finding Description
1.2.1	"The test, middle and upper pipe ram BOP bonnets are original. They have not been subject to OEM inspection and recertification in accordance with API and OEM requirements. Transocean propose a change out plan commencing in 2010 for completion in 2011." **Original BOP Ram never re-certified**
1.3.1	"With the exception of the DP control system a comprehensive software management system for critical software such as the BOP control system, ballast control system and vessel management system could not be demonstrated." **Ballast Control could not be demonstrated**
2.2.1	"The BOP control unit triplex pump pressure relief valve was last recalibrated during August 2007 and subsequently overdue the 2 year recertification period as per API recommended practice." **Pump last re-calibrated in 2007**
2.2.9	"According to maintenance history choke manifold valves have not been opened up for periodic inspection and overhaul in line with API recommended practice. Consequently only valves failing to meet pressure test requirements have been inspected." **Valves not opened, failed pressure tests**
2.2.10	"One of the BOP high pressure boost hoses has been in service since December 1999. The hose is in poor fabric condition and has not been maintained in accordance with Transocean yearly or 5-yearly maintenance requirements. It was communicated that delivery date for a replacement hose was in March 2010." **BOP Boost Hose in service since Dec 1999- in 'Poor Fabric Condition'**
3.2.10	"Much of the well control maintenance was either recorded in the Subsea Engineers daily log book or on various spreadsheets. The level of well control related maintenance history recorded in RMS II was minimal by comparison."

The Communication Record

- Reveals meta-linguistic concerns about the quality of evidence and reasoning, including over-riding concerns about methane and pressure-volume relationships
- Provides non-technical clues to potential problems in the system
- Reveals critical gaps in reasoning about risk, as players focus on logistics of pipe construction
- Reveals lack of integration and articulation of underlying mental models
- **Shows absence of contextual Big Picture oversight**

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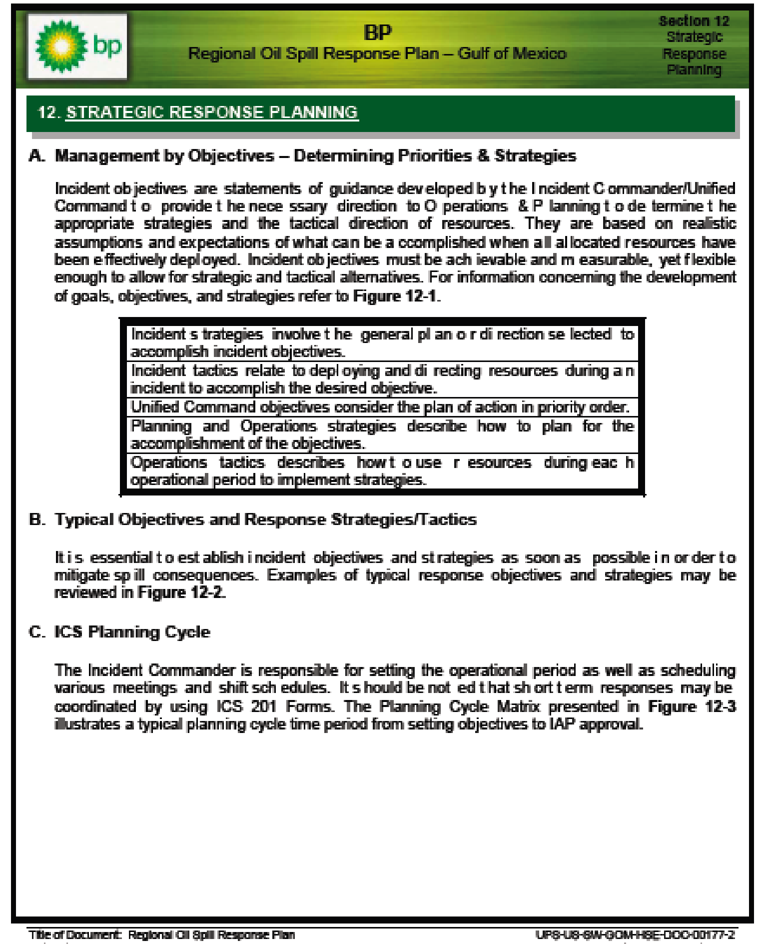
Organizational Response = After the Fact Risk Assessment Strategy



bp

BP
Regional Oil Spill Response Plan – Gulf of Mexico

Section 12
Strategic
Response
Planning

12. STRATEGIC RESPONSE PLANNING

A. Management by Objectives – Determining Priorities & Strategies

Incident objectives are statements of guidance developed by the Incident Commander/Unified Command to provide the necessary direction to Operations & Planning to determine the appropriate strategies and the tactical direction of resources. They are based on realistic assumptions and expectations of what can be accomplished when all allocated resources have been effectively deployed. Incident objectives must be achievable and measurable, yet flexible enough to allow for strategic and tactical alternatives. For information concerning the development of goals, objectives, and strategies refer to **Figure 12-1**.

Incident strategies involve the general plan or direction selected to accomplish incident objectives.
Incident tactics relate to deploying and directing resources during an incident to accomplish the desired objective.
Unified Command objectives consider the plan of action in priority order.
Planning and Operations strategies describe how to plan for the accomplishment of the objectives.
Operations tactics describes how to use resources during each operational period to implement strategies.

B. Typical Objectives and Response Strategies/Tactics

It is essential to establish incident objectives and strategies as soon as possible in order to mitigate spill consequences. Examples of typical response objectives and strategies may be reviewed in **Figure 12-2**.

C. ICS Planning Cycle

The Incident Commander is responsible for setting the operational period as well as scheduling various meetings and shift schedules. It should be noted that short term responses may be coordinated by using ICS 201 Forms. The Planning Cycle Matrix presented in **Figure 12-3** illustrates a typical planning cycle time period from setting objectives to IAP approval.

Title of Document: Regional Oil Spill Response Plan UPS-US-SW-GOM-HSE-DOC-00177-2

Risk Assessment Justified by Financial Impact

- **BP Drilling. Completions. MOC. Initiate 4/15/2010**

  Justification (include financial impact where appropriate):

  - **The current cement model** suggests that we should be able to achieve a successful primary cement job on the long string…
  - The liner, if required, is also an acceptable option, but will add an additional \$7 - \$10 MV to the completion cost….

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‘Seat of the Pants’ Construction Design--Justified by Timing and Availability

- **BP March 25 email (casing)**
  - **Current plan** would be to fun 7” x 9-7/8” tapered long string (saves a lot of time having to tieback the 9-7/8” at least 3 days)
  - If we run a liner, we will use the Atlantis 7-5/8” pipe, no issues cementing the slightly larger size as a liner, but it does cause issues if you run it as a tapered long string.

The ever-evolving ‘Current Plan’

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Risk Decision-Making Driven by Logistics

- **April 16 email (BP1):**
  - Halliburton came back to us this afternoon with additional modeling after they loaded the final directional surveys, caliper log information and the planned 6 centralizers.
  - What it showed, is that the ECD at the base of sand jumped up to 15.06 ppg. This is being driven by channeling of the cement higher than the planned TOC. We have located 15 Weatherford centralizers with stop collars…and worked things out with the rig to be able to fly them out in the morning.
  - **My understanding is that there is no incremental cost with the flight because they are combining the planned flights they already had.**

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Expedience Trumps Concerns

- **BP April 14 Email Correspondence:**
  - Thanks Rich. This has been **a crazy well** for sure.
  - **We have flipped some design parameters around to the point that I got nervous.** I did update my disk calculations and my WellCat model. All looks fine.
  - If we run the 9-7/8" x 7" as a long string, then the design *resembles (It. sic)* the original configuration, at least from an APB standpoint…**I do not have the final disk depth, so I guessed it is around 9.500'.**
  - There is a chance we could run a production liner on Macondo instead of the planned long string…Sorry for the late notice, this has been **nightmare well which has everyone all over the place.**

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Visible Gaps in the Communication Record, Last Minute Additions, Concerns

- April 16 email (BP1):
  - ‘I agree**. This Is not what I was envisioning. I will call you directly.’**
  - ‘We are adding 45 pieces that can come off as a last minute addition. I do not like this and as David approved in my absence I did not question but now I very concerned about using them.’

Players Must Change Underlying Mental Models in the Face of Last Minute Additions—without Adequate Risk Assessment

Data ‘Not Communicated’ or Undocumented

We are not yet certain when Halliburton reported this data internally or whether the test was even complete prior to the time the cement job was poured at the Macondo well. Halliburton reported this data to BP after the blowout.

Taken together, these documents lead us to believe that:

(1) Only one of the four tests discussed above that Halliburton ran on the various slurry designs for the final cement job at the Macondo well indicated that the slurry design would be stable;

(2) **Halliburton may not have had—and BP did not have—the results of that test before the evening of April 19, meaning that the cement job may have been pumped without any lab results indicating that the foam cement slurry would be stable;**

(3**) Halliburton and BP both had results in March showing that a very similar foam slurry design to the one actually pumped at the Macondo well would be unstable, but neither acted upon that data; and**

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Tests 'Redesigned' After Failures

- We have known for some time that the cement used to secure the production casing and isolate the hydrocarbon zone at the bottom of the Macondo well must have failed in some manner.
  - That cement should have prevented hydrocarbons from entering the well….
  - **It appears that Halliburton personnel began a second April foam stability test shortly after receiving the unfavorable results from the first April test.**
  - The results of this test were reported internally within Halliburton by at least April 17, though it appears that Halliburton never provided the data to BP.
    - **Fred H. Bartlett. Oct. 28, 2010 to Commissioners**

BP Ignores Early Indicators of Disaster

- According to BP there were three flow indicators from the well before the explosion.

  - 51 minutes before the explosion more fluid began flowing out of the well than was being pumped in.
  - 41 minutes before the explosion the pump was shut down for a “sheen” test, yet the well continued to flow instead of stopping and drill pipe pressure also unexpectedly increased.
  - 18 minutes before the explosion, abnormal pressures and mud returns were observed and the pump was abruptly shut down.

- The data suggests that the crew may have attempted mechanical interventions at that point to control the pressure, but soon after, the flow out and pressure increased dramatically and the explosion took place.

  - **Source: MEMORANDUM. May 25, 2010. To: Members of the Subcommittee on Oversight and Investigations. Fr: Chairmen Henry A. Waxman and Bart Stupak. Re: Key Questions Arising from Inquiry into the Deepwater Horizon Gulf of Mexico Oil Spill**

‘Unexpected Events’ Ignored

- 5 hours before the explosion, an unexpected loss of fluid was observed in the riser pipe, suggesting that there were leaks in the annular preventer in the BOP.
- Two hours before the explosion, …, the system gained 15 barrels of liquid instead of the 5 barrels that were expected, leading to the possibility that there was an “influx from the well.”
- **Having received an unacceptable result from conducting the negative pressure test through the drill pipe, the pressure test was then moved to the kill line where a volume of fluid came out when the line was opened.**
- The kill line was then closed and the procedure was discussed; during this time, pressure began to build in the system to 1400 psi.
- At this point, the line was opened and pressure on the kill line was bled to 0 psi, while pressure on the drill pipe remained at 1400 psi.

Rapidly Evolving Situation Overwhelms Careful Risk Deliberation and Action

BP Investigation-Appendix Q, p. 3:

- **We discussed the line kill thing [lack of pressure]. I said we need to monitor on the kill line.** Let's open the kill line and see what happens—it started to flow. The cementer called and said it had started to flow. I said shut it in we could have an overbalance. I will talk to [well site leader] and see what he wants to do.
- **I think they closed the IBOP.** Bled 3-4 barrels off the kill line and I told him to go shut it in.

. *(p. 3)*

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… Despite Key Value of Communication During Process

5. Close annular and conduct negative test. After successful negative test, open bag.
6. Continue displacement up the riser until spacer is 500ft past BOP stack (950 bbls 7540 strokes). We can boost riser.
7. Do not shut down until displacement is complete.
8. When WBM spacer returns at 15,968 stks, over-displace until interface is incorporated. When interface is incorporated, Compliance Engineer will take sample for Static Sheen test and ROC and shut down pumps. Switch to overboard discharge.
9. If static sheen is an apparent pass, discharge remaining spacer and seawater down overboard line. Mud Engineer will advise.

NOTE: Good communication will be necessary to accomplish a successful displacement. If you are not sure, stop and ask.

The Test was Successful, but we killed the Patient?

- October 28 Conclusions:
  - The kill line then was monitored and by 7:55 p.m. the rig team was **'satisfied that [the] test [was] successful.'**
  - At that time, the rig started displacing the remaining fluids with seawater, leading to the three flow indicators described above.
  - **BP's investigator indicated that a 'fundamental mistake' may have been made here because this was an "indicator of a very large abnormality."**

- PV=???

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Lessons Learned?

How can Analysis of Communication Improve Risk Assessment without Increasing Administrative Burden?

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Make Sure that all Players Understand the Fundamental Science and Mechanics that Affect the Outcomes of Risk Decisions

There is a not unreasonable expectation that those involved in on-site risk-decision-making understand the basic material consequences of their actions.

Insist that Contractors Articulate Risks & Options--In Writing--Before a Crisis

- *Local Risk Decision—Rapidly Evolving Situation*
  – What's my back-up plan in case of failure?
  – How will the results of my decision affect events downstream in the system?

- *Automated Risk Decision—Rapidly Changing Indicators*
  – What are the planned responses to changing indicators?
  – What Indicators activate Plan B?

- *Big Picture Risk Decision-Making—Before the Crisis*
  – What options are in place?
  – How and upon what conditions will they be activated?

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Place Responsibility for Effective Communication on the Contractor

- Insist on adequate explanations of risks, risk outcomes, prevention, and maintenance.
- Don’t assume that because it’s called a BOP, it will prevent a Blow-out.

If they can’t answer critical questions—in writing, they probably don’t have an adequate plan.

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Attend to Communication Practices

Oral and Written Communication

- Pay attention to meta-linguistic concerns.
- Verify ‘future-talk.’
- Avoid NASA-Fast-Talk.
- Attend to naming practices.

Visual Communication

- Beware idealized drawings.
- Beware re-cycled slides.
- Beware pix that don’t align with oral/written message.
- Beware un-readable data-charts.

Engage Stakeholders at all Levels.

- **Maintenance workers**--who are on the front line in emergencies
- **Administrative staff**--who must make decisions in real time
- **Human resource personnel**--who must plan and execute training
- **Technical experts**--who must anticipate hazards and provide information to assist risk mgt in systems
- **Line Personnel**—who understand risk in physical sites based upon long-term field experience

Create a Top-Down Safety Climate

Management is ultimately responsible
for **creating**,
encouraging, and
understanding
the fundamental science,
communication practices,
safety training, and
reasoning habits that
characterize the **safety climate** in their workplace.

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